valleys; and (2) the form of the range does not agree with the structure of its bed rock series, which latter is variously folded and tilted, in ways not expressed by the physiography, and shows varying degrees of obliquity to the front of the range.

The great erosion of the fault scarp, and lack of erosion of the basalt at its base, shows that the valleys have, during the history of the range as a faulted block, been anything but seats of great erosion; and the great thickness of alluvium and lake deposits shows that they have been areas of deposition.

The following papers for lack of time were read by title:

The Probable Cause of Water Flow in the Mines of Cripple Creek, Colo. By RUFUS M. BAGG, JR., Brockton, Mass.

The Paddles of Shastasaurus. By JOHN C. MERRIAM, Berkeley, Calif.

The Quaternary of the Middle Coast Ranges of California. By ANDREW C. LAWSON, Berkeley, Calif.

ANDREW C. LAWSON,
Secretary.

AUTHORS' ABSTRACTS OF PAPERS READ AT THE WASHINGTON MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA.

Direction of Flow of the Ancient Beaver River, Shown by Pot-holes.

By RICHARD R. HICE.

THE evidence of the slope of the remaining fragments of abandoned fluvial plains may not always be conclusive as to the direction of flow of the stream that formerly flowed over them. Pot-holes, one of the features of stream erosion, are conclusive. On the Beaver River from Beaver Falls to below the Fallston dam, the present channel, cut in the Homewood Sandstone, is marked by typical pot-hole erosion. Views of pot-holes below the Fallston dam show in all cases that the up-stream side of the hole is abrupt, and often undercut, while the down-stream side is rounded off and eroded by the action of the flowing water. This also applies to channels formed by

[1] *Science*, September, 1901, p. 457.

pot-holes cutting into one another. Near Rock Point the abandoned bed of the old stream, 150 feet above the present stream, is also in the Homewood Sandstone. A number of pot-holes have been seen here, and views show that the steep side is on the southern side, and the eroded, rounded side on the northern side of the hole, thus clearly indicating that the former stream flowed northward.

The fragments of the bed of this old north-flowing Beaver are practically level from Pittsburg to Rock Point, a distance of about forty miles. The next fragments found a few miles north of these pot-holes are, however, some 80–100 feet lower than at the pot-holes. Observation shows that pot-holes are formed only where the stream is very rapid, and these pot-holes, therefore, indicate that the old north-flowing stream had a greatly increased fall northward for several miles, and a series of rapids here occurred, or perhaps a fall. The pot-holes, therefore, bring the fragments farther north (810 feet) into harmony with the level at the pot-holes (900 feet), and harmonize the almost horizontal fragments southward to Pittsburg, with the 80–100 feet of fall found immediately northward.

Ames Knob, North Haven, Maine; A Seaside Note. By BAILEY WILLIS, Washington, D. C. (Abstract of Paper to Appear with Illustrations in *Bull. G. S. A.*)

AMES KNOB is a mass of andesitic volcanic rock rising 160 feet above the sea, on the neck of land between the Fox Island thoroughfare and South Harbor, North Haven Island, in Penobscot Bay. Its petrographic character and geologic relations have been described by G. O. Smith, in his essay on the geology of the Fox Islands, Me. It is bounded on the north by a low plain cut in shales and limestones, of Niagara age, and its northern slope is a cliff resulting from the relatively great hardness of the igneous rock. The other slopes of the knob are of practically uniformly resistant rock, and variations in profile are attributable to conditions of attack, rather than of resistance. At an altitude of approximately 80 feet above the sea, on the southeastern and southern sides facing the Atlantic ocean, is a well-marked bench from which a steep facet rises 40 to 60 feet to the summit of the knob. This bench, which has an average width of about 200 yards, is attributed to the action of waves cutting at rock level. The rocks in place exposed upon this bench and about its margin exhibit rounded glaciated profiles, but no longer bear striæ, so far as observed. Hence

it is inferred that the date of submergence to this level preceded and continued to the latest episode of glaciation, and that later influences have removed the minor evidences of ice action. Upon this glaciated bench there are now deposits of glacial gravel having the characteristic forms of spits and bars, which are accordingly attributed to wave and shore currents. These deposits indicate the presence of the sea at this level after the retreat of the ice.

The simplest explanation of the facts is that Ames Knob was submerged beneath the sea to a depth of 80 feet above the present sea level before, during, and immediately after the latest glacial episode.

Permian Elements in the Dunkard Flora. By DAVID WHITE.

THE Dunkard series (Upper Barren Measures, XVI) comprises the topmost Paleozoic sediments in the Appalachian trough. It occupies a considerable area in southwestern Pennsylvania, northern West Virginia, and eastern Ohio, and the total thickness in northern West Virginia is probably over 1,200 feet. In the absence of marine organisms, the determination of the age of the beds rests on the fossil floras, the only important palæontological evidence at present available.

Extensive plant collections made at several localities were fully described in 1880 by Professors William M. Fontaine and I. C. White, who from their study of the flora and the lithology concluded that the entire series was Permian. This conclusion has been questioned by some American geologists and palæobotanists on account of the large proportion of Coal-measures types, the paucity of genera and species characteristic of the Permian of Europe, and the similarity as well as continuity in the sedimentation.

Additional material recently collected materially increases the number of identical characteristic Permian species, which now includes three species of *Callipteris*, in or above the Washington limestone, while the examination of the types in other genera emphasize the Permian aspect of a number of other forms. The data now available leave little room for doubt that the upper part, of the Dunkard at least is Permian, the stratigraphical occurrence of the species rendering it probable that the beds down to and including the Washington Limestone, about 175 feet above the base of the series, may with safety be referred to that period. The evidence as to the age of the lower beds of the series is, in the judgment of the writer, not yet suffi-

ciently complete to be satisfactory or conclusive. On account of the continuity in sedimentation, with little epeirogenic movement and but slight lithological differences as compared with the preceding formations, and on account of the presence of a transitional flora including many persistent Upper Coal-measures species, a much more thorough investigation of the plant fossils of the Dunkard and Monongahela measures will be necessary before the boundary or approximate limit between the Coal-measures and the Permian can be drawn.

Walchia and *Ullmannia*, though present in other Permian basins of this continent, have not yet been found in the Appalachian trough. The upper part of the Dunkard is referable to the Rothliegende, probably to the Lower Rothliegende. Beds of the Zechstein or Upper Permian do not appear to have survived in the Appalachian basins.

Glacial Bowlders Along the Osage River. By E. R. BUCKLEY, S. H. BALL, AND A. T. SMITH.

THE discovery of glacial bowlders along the Osage river, fully thirty miles south of the known southern limit of the ice sheet, was simply an "episode" in the systematic strategraphic work which the Missouri Bureau of Geology and Mines is at present conducting in the Ozark region. The fact, however, that in no less than eight localities along the Osage river in Miller county granitic bowlders of undoubted foreign origin were observed is in itself a contribution to the glaciology of this region. This discovery also has a bearing on the physiographic history of the region, giving evidence of the age of the Osage river channel.

In brief it may be said that, if one were to include foreign erratics of all sizes observed at the eight localities, he might perhaps account for several hundred bowlders. These bowlders consist of several varieties of granite, granite-gneiss, and diorite. They range in size from pebbles having a diameter of several inches to bowlders three feet in diameter.

They occur along the present river channel and also back from it, along the tributary streams. In no case, however, were they found at a greater elevation than 605 feet A. T., which in that region is about 70 feet above the low-water level of the Osage river. Nowhere on the ridge land between the Osage and Missouri rivers is there any evidence of glaciation.

The evidence at hand warrants us in believing that the glaciers did

not override the ridge land to the north and that the bowlders above referred to do not indicate the former extension of the ice sheet to that point. Although it has lately been pointed out that the ice sheet extended beyond the head waters of the Osage river in Kansas, it is thought very improbable that these bowlders could have been carried that distance on ice floes. The more reasonable explanation of their present location is through icebergs or floating ice carried from the Missouri river on back-water caused by an ice-jam below the mouth of the Osage. This is the present accepted explanation of their origin. Other explanations, such as changes in the course of the river, have not proved tenable.

Accepting the above explanation of the source of the bowlders, it leads to the important conclusion that the channel of the Osage river was, in part at least, defined prior to the glacial period. The history of the Osage river, with its meandering course as it flows between steep cliffs on either side, has presented to the geologists of Missouri a very interesting problem in physiography, and one which has not yet been settled. It is hoped that this occurrence of glacial bowlders will be of some assistance to the next physiographer who undertakes to read the history of the river.

Age of the Atlantosaurus Beds. By WILLIS T. LEE.

THE paper deals with the southern extension of the Atlantosaurus beds along the eastern foothills of the Rocky Mountains into New Mexico, and shows that certain shales in the Canadian Canyon are probably equivalent to these beds. The shales are also traced south and east from their type localities through a new Dinosaur locality and into Oklahoma, where shales, which are apparently the continuation of the Dinosaur beds, contain fossils of Lower Cretaceous type. The observations thus tend to confirm the opinion held by many geologists that the Atlantosaurus beds are of Lower Cretaceous age.

On the Porphyritic Appearance. By ALFRED C. LANE.

THERE are some five different kinds of phenocrysts, or crystals, which may give a porphyritic appearance, viz:

Coarser relics of a previous consolidation.

Crystals whose formation took place during the migration of the igneous magma.

Crystals which were formed early in the process of cooling and

solidification so that their grain continues to increase clear to the center, while later-formed constituents increase only for a shorter distance, their grain thereafter remaining uniform. This porphyritic type will be most obvious at the center of the igneous mass.

Crystals, the conditions (temperature) of whose formation were nearly half way between those obtaining initially in the igneous magma and the country rock. Such crystals will be most conspicuously porphyritic at or near the margin.

Finally there may be crystals, which like the staurolite of schists, are formed by metamorphic actions, of secondary origin, and occur in sediments, and only casually occur in igneous rocks.

Attention is particularly called to the third and fourth classes, the possibility of the existence of which has been almost overlooked, though their possible existence may be readily inferred from inspection of diagrams of the cooling of an intrusive. Certain field observations render their actual existence probable.

The Basal Conglomerate in Lehigh and Northampton Counties, Pennsylvania. By FREDERICK B. PECK, Easton, Pa.

THE term "basal conglomerate," as here used, refers to that lowest member of series of beds, belonging to the Cambrian, which lies uncomformably upon the pre-Cambrian gneisses, but is conformable with the overlying lower Cambrian dolomites. It occurs here, as elsewhere in Pennsylvania and New Jersey, fringing the pre-Cambrian areas. In eastern Northampton county it fails occasionally as a result of faulting. It has a thickness varying from a few feet near Easton to one hundred or possibly several hundred feet at Alburtis, twenty-four miles southwest of Easton.

Petrographically, it is quite variable. At times it is a coarse conglomerate, made up of quartz pebbles, an inch or two in diameter. Frequently it is a medium to fine grained arkose, consisting of about one part feldspar (orthoclase or microcline) to two or three parts quartz, the former usually thoroughly kaolinized, the latter badly crushed, and under the microscope exhibiting an undulating extinction. Other phases of it present a dense bluish or grayish quartzite. It occasionally contains interstratified beds of a very fine-grained argillaceous sandstone with numerous worm borings (scolithus), but as yet no distinctly lower Cambrian fossils have been found. The seemingly uppermost member is a highly ferruginous, almost jaspery

quartzite, which locally contains iron enough to constitute a low-grade ore. From this horizon a considerable amount of iron ore was formerly obtained. The lowest member of the series, in a number of instances, was found to pass by almost imperceptible gradations into the underlying granitoid gneiss, in such a manner as to suggest the decidedly rapid submergence of a deeply weathered Cambrian land mass, with a correspondingly rapid advance of the sea over the same, affording insufficient time either for the thorough sorting of the loose materials already at hand or the bringing in of any considerable amount of sediment from a distance. The entire basal series, representing, as it does, distinctly littoral or at least shallow-water deposits, has a total thickness of only a few hundred feet at the most, and the conditions under which it was deposited must have rapidly changed to those necessary for the deposition of the off-shore and distinctly deep-water sediments represented by the two or three thousand feet of dolomites and the dolomitic limestones, which immediately succeed it.

The series is the northeastern extension of beds which in York county have been called by Walcott "the Hallam quartzite"[1] and is the equivalent of the Hardiston quartzite of Kümmel and Weller[2] in northern New Jersey.

Post-Glacial Time. By A. H. ELFTMAN.

HITHERTO the St. Anthony gorge has been ascribed to the St. Anthony falls, which is regarded as having decreased in height from Fort Snelling to Minneapolis. Several features of the gorge were described, showing that it was formed largely by rapids. The falls did not assume prominence until two miles above Fort Snelling was reached, and they have been increasing in height. Account is taken of the terraces in the Mississippi valley, and the differential uplifts are recognized as affecting this region. The gorge represents a much longer period of time than has been assigned to it. This is further strengthened by the evidence afforded in the postglacial gorge of the St. Croix river.

The Relation between the Keewatin and Laurentide Ice-sheets. By A. H. ELFTMAN.

EVIDENCE was presented to show that the glacial drift of the upper Mississippi river valley was deposited by independent lobes of the

[1] *Bull. U. S. Geol. Surv.*, No. 134, 1897.

[2] *Bull. Geol. Soc. Am.*, Vol. XII, pp. 149 ff.

Keewatin and Laurentide ice-sheets, alternating in their advance and retreat.

A lobe of the Keewatin ice-sheet first invaded this region from the northwest and extended into Iowa and to western Wisconsin. This lobe formed the Kansan drift in Minnesota and the Kansan and pre-Kansan drift further south. Glacial Lake Grantsburg was formed in the upper Saint Croix valley, and for a time had its outlet northward into Lake Superior. The retreat of this ice was followed by a marked interglacial period.

The second great ice invasion, the Iowan, came from the northeast. The Rainy Lake and Lake Superior lobes of the Laurentide ice-sheet extended to western Minnesota, and the latter lobe was deflected southward into Iowa. This ice does not appear to have retreated far beyond the limits of Minnesota, and was followed in this region by a comparatively short interglacial period.

During the third invasion, the Wisconsin, the Minnesota lobe of the Keewatin ice-sheet again advanced from the northwest across central Minnesota into Iowa. At the same time the lobes from the Laurentide ice-sheet advanced southwestward until they reached the northeastern limit of the Minnesota lobe. The final retreat of the three lobes was contemporaneous, forming glacial lakes and numerous moraines. The Keewatin ice-lobe appears to have completely retired from Minnesota slightly before the lobes of the Laurentide ice.

A new mapping of the moraines formed by the various lobes during their final retreat is presented in support of the views advanced.

The movements of the several lobes of the Laurentide ice-sheet present a combination not noticed heretofore. The lobes from Green Bay and Lake Michigan eastward over the Great Lakes show three well-defined advances—the Illinoian, Iowan, and Wisconsin. The Chippewa, Lake Superior, and Rainy Lake lobes show two advances, the Iowan and Wisconsin. The western lobes in Canada, north of Minnesota, show only one advance, the Wisconsin.

It appears that the advance of the northern part of the ice-sheet to the west was much slower than the advance to the south, and the time required for the Laurentide ice-sheet to reach Lake Winnipeg was sufficiently long to allow of two and three advances and retreats in other portions of the ice-sheet.

The Bellefonte, Pa., Section of the Ordovician. By GEORGE L. COLLIE.

THE section described is located at Bellefonte, Pa., the geographical center of the state. It lies in the Nittany valley, a denuded anticline, between the isoclinal Bald Eagle ridge on the northwest and the synclinal Nittany ridge on the southeast.

The rocks dip to the northwest, the dip varying from 8° at the crest of the anticline to 80° and 90° at the top of the section in Bald Eagle ridge. The total thickness of rocks in the section is 6,000 feet, of which 5,000 feet are limestones and 1,000 feet shales. The lithological features of the rocks have been described in detail in the various geological reports of the state, and do not need further description. Little attention has been given to the faunas found in the rocks, and this paper aims in a measure to supply this deficiency.

Four fossiliferous horizons have been recognized in the limestones and two in the shales. The lowest horizon (A^1 of the paper) is 345 feet above the base of the section. It occurs in an oolitic limestone and is but a few inches in thickness. Ophiletas are the most abundant types found, though Murchisonias occur sparingly. The Ophiletas are related chiefly to *O. Complanata.* This indicates the Calciferous age of this horizon.

Between this lowest horizon and the next succeeding horizon (A^2) there are 600 feet of unfossiliferous rocks. Horizon A^2 contains a mixed fauna. Its relationships are in part with the Calciferous, in part with the Quebec, and in part with the Chazy. The most abundant fossil is *Asaphus Marginalis*, a Chazy form in New York. Various species of Ecculiompholus occur, all of which are closely related to forms described by Billings from the Quebec of Canada. *Ribenia Calcifera* and *Ophileta Uniangulata*, typical Calciferous fossils, are found also. Provisionally this horizon is referred to the Calciferous. Above A^2 are 1,200 feet of unfossiliferous rocks before the third horizon A^3 is reached.

Horizon A^3 is characterized by an overlapping of faunas. Stratigraphically speaking, the horizon is Chazy, but it contains few Chazy fossils. The relationships of the fauna are with Canadian and Newfoundland types rather than with those of the interior as represented in New York. The most interesting fossil found is *Bothyurus amplimarginatus*, a form described by Billings from the Calciferous of the Mingon Islands, Gulf of the St. Lawrence. *Macluna Magna, M. Affinis, M. Acuminata* are common. The mention of these names

gives some idea of the commingling of faunas at this horizon. For the present this horizon is referred to the Chazy. Two thousand feet of unfossiliferous rocks intervene between this horizon and the Trenton horizon, A^4. The total thickness of the exposed Calciferous is about 1,900 feet; of the Chazy, 2,200 feet; of the Trenton, 900 feet.

Unlike the lower horizons, the faunas of A^4 are closely related to those of New York. They need no description in this place, the only unusual form found being a Brougniartia, a homalonotoid trilobite, which is quite common in the shaly limestones at the top of the Lower Trenton. The shales of the section are fossiliferous at the base and again at the top. The intervening beds are not fossiliferous. At the base the characteristic Utica form, *Triarthrus Beckii*, is very common; its vertical range is 300 feet, and this is taken to be the thickness of the Utica shale. The Lorraine shales contain characteristic fossils similar to those found in similar horizons in New York. Not only is there a marked similarity in the fossils, but in the lithological features of the rocks, indicating very similar conditions in the two fields. During the earlier stages of the Ordovician there seems to have been free communication between Pennsylvania and the Canadian provinces. In the later Ordovician this seems to disappear, and direct communication is established with central New York.

The Devonian and Carboniferous of Southwestern New York. By L. C. GLENN.[1]

THE paper is based on work done by the United States Geological Survey, in co-operation with the states of New York and Pennsylvania, in the areal geological mapping of the Olean and Salamanca quadrangles, together with reconnaissance work southward and westward in Pennsylvania.

The oldest rocks exposed are the upper 700 feet of the Chemung, consisting of argillaceous and sandy shales, with the Cuba sandstone as a thin lentil near the bottom. The Wolf Creek conglomerate succeeds the Chemung and is regarded as a lentil marking the base of, and belonging to, the Cattaraugus shale formation. It is a flat pebble conglomerate, quite variable in thickness, but usually thin and inconspicuous, and thins out and disappears westward on the Salamanca quadrangle. Bright red shales first appear within a few feet above the Wolf Creek and with interbedded greenish shales and soft, fine, greenish-

[1] Published by permission of the Director of the U. S. Geological Survey.

gray, micaceous sandstones characterize the next 300 to 350 feet. This red-shale interval constitutes the Cattaraugus formation. In its upper part a second lentil, the Salamanca conglomerate, occurs. It lenses out eastward, but becomes prominent westward in the Salamanca region and is regarded as the same as the Pope Hollow and Panama conglomerates farther west. A third lentil, called the Kilbuck conglomerate by Mr. M. L. Fuller, occurs about 50 to 70 feet above the Salamanca. It is found in the Salamanca region only.

The next formation is the Oswayo, characterized by rusty olive colored, limonitic sandy shale, from 160 to 250 feet thick. Over this the Sub-Olean, or Shenango, conglomerate is found in some areas, usually 20 to 30 feet thick, but apparently cut out in other places, and on the Olean quadrangle losing its conglomeratic character and merging into a sandy shale similar to the Oswayo shale. Over it, when not apparently cut out also, are 30 to 50 feet of Sub-Olean, or Shenango, shale. This is overlaid by the Olean conglomerate, usually massive and round-pebbled, 50 to 90 feet thick. A few feet of thin, rusty, sandy Sharon shale overlies the Olean conglomerate at Rock City.

The shales below the Wolf Creek are Devonian. From the base of the Wolf Creek to the top of the Oswayo a mingling of Devonian and Carboniferous faunas makes it best to designate these rocks, for the present, as Devono-Carboniferous. Above the Oswayo the rocks are regarded as Carboniferous.

The rocks dip 25 to 30 feet per mile slightly west of south. Minor rolls causing local reversals of dip are known to occur.

AUTHOR'S ABSTRACTS OF PAPERS READ AT THE WASHINGTON MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. SECTION E.

Geological Age of the West Indian Volcanic Formations. By J. W. SPENCER.

THE Greater Antilles appear to be nearly devoid of volcanoes. The writer has seen only the remains of one in Jamaica (at Low Layton), and none in Cuba. But there are extensive underlying igneous formations in all these islands. However, in the inner zone of the Caribbean or Windward Islands there are many cones, and beneath these and the outer islands there is an underlying volcanic basement. In such of the outer islands as St. Martin, and better still in Antigua, and in St. Croix one gets some knowledge of the antiquity of the